MODELING SINGLE-EVENT TRANSIENTS IN COMPLEX DIGITAL SYSTEMS

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A methodology to determine the effect of single-event transients (SETs) on complex digital systems has been developed. This methodology is based on the SET state-transition model. This model breaks the complex digital system down into five states. These states are the error-free/transient-free state, the logic-gate transient state, the single-event-upset (SEU) state, the output-driver transient state, and the failure state. The state-transitional probabilities of the model are determined by SET generation modeling, SET propagation modeling, and SEU propagation modeling. SET generation and propagation are primarily modeled using SPICE. SEU propagation modeling is accomplished using a combination of VHDL fault-injection modeling and mode-dependent (or instruction-based for a processor) register-usage analysis.

To verify this methodology, the SET tolerance of a 16-bit RISC microprocessor, the KDLX, was predicted. The transitional probabilities for this processor were determined, and the effective cross-section of the processor for three different test programs was predicted. Laser testing was performed on the KDLX to validate the predicted transitional probabilities. Heavy-ion testing was performed to validate system-level predictions. The results from the heavy-ion testing show that the methodology accurately predicts the saturated effective cross-section of a complex digital system.

KEYWORDS: Single-Event-Transients, Single-Event-Upsets, Single-Event-Effects, Transient Fault Propagation

DOCTOR OF PHILOSOPHY

SPECIFYING QUALITY OF SERVICE FOR DISTRIBUTED SYSTEMS BASED UPON BEHAVIOR MODELS

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The substantial complexity and strict requirements of distributed command and control systems creates an environment that places extreme demands upon system resources. Furthermore, inconsistent resource distribution also introduces the distinct possibility of potential errors, and process failures. Many of these potential difficulties can be understood and addressed through a practical analysis of the resource management and distribution procedures employed within these systems. This analysis should include a direct focus upon the essential quality of service that is shared among the software programs that operate within this environment. However, the current approaches to this analysis are lacking in that there is no accurate method to determine precisely what quality of service based conflicts take place during program execution. This problem can be addressed through examination of specific quality of service actions during program execution. To achieve a precise analysis of quality of service actions this dissertation research has implemented an approach to examine the exact quality of service execution path during program operation.

KEYWORDS: Event Trace, Behavioral Model, Quality of Service, Command and Control

HETEROGENEOUS SOFTWARE SYSTEM INTEROPERABILITY THROUGH COMPUTER-AIDED RESOLUTION OF MODELING DIFFERENCES

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Meeting future system requirements by integrating existing stand-alone systems is attracting renewed interest. Computer communications advances, functional similarities in related systems, and enhanced information description mechanisms suggest that improved capabilities may be possible; but full realization of this potential can only be achieved if stand-alone systems are fully interoperable. Interoperability among independently developed heterogeneous systems is difficult to achieve: systems often have different architectures, different hardware platforms, different operating systems, different host languages and different data models.

The Object-Oriented Method for Interoperability (OOMI) introduced in this dissertation resolves modeling differences in a federation of independently developed heterogeneous systems, thus enabling system interoperation. First a model of the information and operations shared among systems, termed a Federation Interoperability Object Model (FIOM), is defined. Construction of the FIOM is done prior to run-time with the assistance of a specialized toolset, the OOMI Integrated Development Environment (OOMI IDE). Then at runtime OOMI translators utilize the FIOM to automatically resolve differences in exchanged information and in inter-system operation signatures.

KEYWORDS: Interoperability, Model Correlation, Heterogeneous Software Systems, XML, Data Binding, Modeling Difference Resolution

DOCTOR OF PHILOSOPHY

A MULTIDISCIPLINARY ALGORITHM FOR THE 3-D DESIGN OPTIMIZATION OF TRANSONIC AXIAL COMPRESSOR BLADES

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A new, multidisciplinary algorithm for the CFD design optimization of turbomachinery blades is presented. It departs from existing techniques in that it uses a simple, previously-developed Bezier geometry representation (BLADE-3D) that can be easily manipulated to achieve true 3-D changes in blade shape. The algorithm incorporates zero and first-order optimization techniques including sensitivity analyses and one-dimensional search methodology. It features an iterative finite element structural analysis as well as a cold shape correction procedure to ensure that the resulting blade meets steady-stress structural requirements. The process was applied to two different transonic fan designs – the Sanger rotor designed for the NPS Turbomachinery Laboratory and NASA Rotor 67, otherwise known as the 'NASA Fan.' The optimization objectives for the two designs were mass flow rate and polytropic efficiency respectively. Results for the Sanger rotor effort yielded an 8.1 % improvement in mass flow rate, a 5% improvement in total pressure ratio, and a 0.9 % increase in adiabatic efficiency. Application to the NASA Fan resulted in a 2.5 % increase in polytropic efficiency. The results validate the utility of the BLADE-3D Bezier geometry package for use in future development of automated optimization routines for turbomachinery blade design.

KEYWORDS: Design Optimization, Transonic Fan Blades, Bezier Geometry Package

DOCTOR OF PHILOSOPHY

A COMPUTATIONAL MODEL AND MULTI-AGENT SIMULATION FOR INFORMATION ASSURANCE

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The field of information assurance (IA) is too complex for current modeling tools. While security analysts may understand individual mechanisms at a particular moment, the interactions among the mechanisms, combined with evolving nature of the components, make understanding the entire system nearly impossible.

This dissertation introduces a computational model of IA called the Social-Technical Information Assurance Model (STIAM). STIAM models organizations, information infrastructures, and human actors as a complex adaptive system. STIAM provides a structured approach to express organizational IA issues and a graphical notation for depicting the elements and interactions. The model can be implemented in a computational system to discover possible adaptive behavior in an IA environment. A multi-agent simulation is presented that introduces several innovations in multi-agent systems including *iconnectors*, a biologically inspired visual language and mechanism for inter-agent communications.

The computational model and simulation demonstrate how complex societies of autonomous entities interact. STIAM can be implemented as a hypothesis generator for scenario development in computer network defensive mechanisms.

KEYWORDS: Information Assurance, Information Security, Computer Security, Security Model, Modeling, Agents, Multi-Agent System, Multi-Agent Simulation